Specific Transport & Storage Solutions : Waste Management facing current and future stakes of the nuclear fuel cycle

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ABSTRACT

With major projects ongoing or being planned, and also with the daily management of radioactive waste from nuclear facilities, the role of transport and/or storage packaging has been often overlooked. Indeed, the packaging development process and transport solutions implemented are a key part of the waste management challenge : protection of people and of the environment.

During over four decades, the AREVA Group has developed a complete and coherent system for the transport of waste produced by nuclear industries. The transport solutions integrate the factors to consider, as industrial transportation needs, various waste forms, associated hazards and current regulations. Thus, TN International has designed, licensed and manufactured a large number of different transport, storage and dual purpose cask models for residues and all kinds of radioactive wastes.

The present paper proposes to illustrate how a company acting both as a cask designer and a carrier is key to the waste management issue and how it can support the waste management policy of nuclear waste producers through their operational choices.

We will focus on the TN International technical solutions implemented to guarantee safe and secure transportation and storage solutions. We will describe different aspects of the cask design process, insisting on how it enables to fulfil both customer needs and regulation requirements. We will also mention the associated services developed by the AREVA Business Unit Logistics (TN International, TRANSNUCLEAR, MAINCO, and LMC) in order to manage transportation of liquid and solid waste towards interim or final storage sites.

INTRODUCTION

During the 20th century, the various applications of radioactivity worldwide have generated several types of radioactive waste. Most of this waste comes from nuclear power plants, spent fuel reprocessing plants and civil and military nuclear facilities which have been operating for a number of decades. Research facilities, nuclear medicine department, national defence activities, and some industries using radioactive materials also produce nuclear waste that has to be managed.

The level and type of radioactivity, as well as its physical and chemical nature, can vary greatly from one kind of waste to another. The hazards posed to people and the environment also differ widely depending especially on how the waste has been processed.

Regardless of whether the waste comes from the fuel cycle or medical, industrial or research activities, each kind of waste requires the implementation or the development of specific processing and management issues, appropriate to the relevant risks. The main stages of radioactive waste management include: treatment, packaging, and interim storage or final disposal. The processing and packaging operations prepare the way for storage or final disposal. Each waste management stage requires transportation operations.

RADIOACTIVE WASTE CLASSIFICATION

The various kinds of nuclear waste have to be classified so as to establish the transportation needs. Classification can be based on the nature of the waste. Classifying radioactive waste is a complex field. Indeed, all types of classification are connected with national laws which define the domestic classification. Classification practices can therefore differ from one country to another.
In France, the classification of radioactive waste is based on two parameters: the activity level and the nuclear decay (half-life). The categories are described below, as illustrated in Figure 1, which also mentions the current storage solutions and those being studied :

- High Level Waste (HLW)
- Long-Lived Intermediate Level Waste (LL-ILW)
- Long-Lived Low Level Waste (LL-LLW)
- Short-Lived Low- and Intermediate- Level Waste (SLL-ILW)
- Very Low Level Waste (VLLW)

High level activity waste and long-lived intermediate level waste

These kinds of waste account for the largest share of radioactivity in France while they constitute a small volume. High level waste comes from the fission products and the minor actinides coming from spent fuel. They are conditioned in vitrified waste canisters after reprocessing operations. The HLW have a very high concentration of radionuclides and gives off heat, an average of 1,900 watt per canister at the time of vitrification. Long-lived intermediate level waste mostly comes from spent fuel structures (cladding hulls and end caps) or residues from nuclear facility operations (waste from effluent treatment, equipment). In France, all of this waste is currently stored at spent fuel reprocessing plant sites and in CEA Research centres.
T*he radioactivity of high level waste stands at a few tens of billions Becquerel per gram.*
The radioactivity of long-lived intermediate level waste generally stands between one million and one billion Becquerel per gram.

Long-lived low level waste

This concerns radium-bearing waste and graphite waste. Radium-bearing waste contains a substantial amount of Radium 226 and/or Thorium 232 and/or Uranium 235. On the whole, this waste is produced through the use of naturally-occurring raw material in radioactive industrial processes, such as the extraction of rare earths. The process leaves a part of the radioactivity in the residue. Its radioactivity is mainly of the alpha type. Luminous paint, objects like lightning rod heads, as well as a part of the cleanup waste from contaminated soil fall under this category. Graphite waste comes from the graphite moderated gas-cooled reactors. It is characterized by a significant presence of long-lived radionuclides.
The radioactivity of radium-bearing waste stands between several tens and several thousands Becquerel per gram.
The radioactivity of graphite waste stands between several 10 000 and several 100 000 Becquerel per gram.

Short-lived low- and intermediate level waste

This is mainly maintenance waste (equipment, tools, cleaning cloths, etc.) or facility operating related waste, as the waste produced by the processing of liquid and gas effluents in nuclear facilities. The waste can also come from dismantling operations.
Waste with substantial amounts of tritium must undergo specific treatment due to the difficulties in containing tritium. Most of this waste comes from defence activities and are currently stored.
The radioactivity of this waste generally stands between a few hundred and one million Becquerel per gram.

Very low level waste

This waste mainly comes from the decommissioning of nuclear facilities and from conventional industries which use naturally-occurring radioactive materials. It can also concern the facilities' operating waste and cleanup waste from contaminated sites. This waste is generally inert (concrete, dismantled equipment, etc.) and similar with common industrial waste or classified as hazardous by French law, viz. containing toxic chemical species.

The radioactivity of this waste is generally below 100 Becquerel per gram.

Table I. French classification of radioactive waste and related long-term management solutions (source: ANDRA = Agence Nationale pour la gestion des déchets radioactifs, National Radioactive Waste Management Agency)

	Short Lived (SL) waste (main elements < 30 years)	**Long Lived (LL) waste** (main elements > 30 years)
Very Low Level Waste (VLLW)	Surface VLLW ANDRA disposal facility (Morvilliers – Aube)	
Low Level Waste (LLW)	Surface LLW ANDRA disposal (Soulaines – Aube)	Under study (for waste with *graphite and radium*)
Intermediate Level Waste (ILW)	Under study (for waste with *tritium*)	Under study
High Level Waste (HLW)	Under study	

TRANSPORT SOLUTIONS IMPLEMENTED FOR WASTE TRANSPORT

Packaging design & development process

The design of transportation packages must consider industrial transportation needs, physical and chemical forms of the waste, associated hazards and current regulations.

The packages are designed to withstand potential hazards, in accordance with the material they have to transport. TN International ensures their compliance with international and national regulations and customer requirements and optimizes testing procedures. This is achieved through quality assurance and compliance assurance programs.

In addition to the safety constraints, the package must comply with all the mechanical interfaces from the consignor site to the consignee site. This means that the overall dimensions of a cask and its weight must be adapted to the loading and unloading areas (dimensions and capacity of handling means). The transport means by road, rail and sea for overseas transports have also to be considered.

Current solutions proposed by TN International

The AREVA Group has developed a complete and coherent system for the transport of waste. This system is based on standardized waste conditioning and transport packaging systems well adapted to the specification of waste to be shipped.
To set up this transport policy, TN International has developed a full range of services and packages adapted to the characteristics of liquid and solid waste, final and interim storage facilities, and specific customer needs, complying with a stringent regulatory context and cost-effectiveness.

Considering the specificities and classifications of the materials involved, we will focus our description on the main activities of TN International which concern:

- Firstly, the transport of Very Low level waste (VLLW) and Low Level Waste (LLW) characterized by the “large” volume shipped, which requires transport optimization,
- Secondly, the transport of Intermediate Level Waste (ILW) and High Level Waste (HLW), which involves highly qualified competencies in cask design and development.

Transport of Low Level and Very Low Level waste (LLW & VLLW)

The LLW and VLLW are distinct from HLW by their large volumes and diversities of physical form. These kinds of waste coming from dismantling operations are characterized by their low activity with short lived elements.
The main constraint is to transport a maximum volume and various forms of waste.

Shipment of large volumes:
In France VLLW and LLW represent more than 4000 transports per year. With such large volumes, this kind of transport is not trivial. The carriers and transport companies must be faultless. The carrier has to be able to manage efficiently in term of communication in case of crisis situation.

The transport of these wastes is adaptable to different modes of transport and especially the rail transport. Indeed, in France, thanks to a well developed railway network, 25 % of production sites are rail connected. The rail transport environment offers high safety /security. It is also more flexible than road transport: a last minute re-routing is always feasible.

Non-reusable transport packaging:
Concerning the transport of VLLW, majority of the package concerned cannot be reused. These packages are used for transport and final storage.

Packaging transport permit the storage in final disposal area:
For VLLW, MAINCO has developed a primary package that has allowed a significant optimization of the transportable volume of waste.

A steep increase of transport flows in the next 10 years:
Concerning the increase of flow in the next 10 years, the best way to face these changes of environment is to improve on creativity and innovation in order to propose solutions helping industrials to face the market trends. The key of a successful logistics chain of waste is a scheme of transport able to provide the highest level of safety and reliability.
New transport schemes must be implemented, not to replace them but to provide alternative solutions to existing and proven solutions.

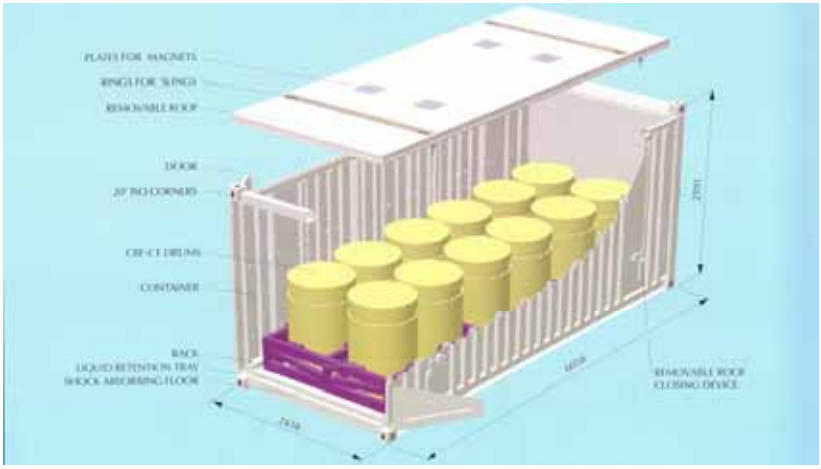
Future challenges, waste from dismantling operations:
We need to anticipate the shape of future waste and their conditioning according to their characterization at source (LLW or VLLW).
We are in touch with the most interesting part of the logistician field: the possibility to create a strong partnership with the producers at the initialization of the project, in order to provide to producers right and cost effective solutions for conditioning and transport.

Transport packaging of IP 2 type and IP 2 package:
As a radioactive material transport specialist, we have to keep the producers informed about the necessity to use not only an IP 2 type container (which indeed is not enough to fulfill regulatory obligations), but also a **qualified IP 2** package. In 2005, the Safety Authorities have reinforced their position on this issue. Indeed, due to a common thought that the “transport of LLW and VLLW is not highly technical”, on a competitive market, it would be dangerous to consider a transport company not specialized in the nuclear field. Commissioning and transport operations require a well-proven experience including technical, administrative and safety framework, for safe transportation.

For all the arguments described above, concerning the VLLW and LLW, these types of waste require beyond a transport company, they require a logistician company able to take in charge the packaging development, transport solutions and global management of these waste, including regulatory compliance and crisis management.

SOME EXAMPLES OF STANDARDIZED PACKAGES

DV78 Package



IP2 packaging
Based on 20’ ISO hard top container
Single locking pad for both
doors and removable roof
Shock absorbing floor
Several racks for various contents

Characteristics
One shell, more than 10 IP2 different contents and a IP2 package conformity certificate with 55 containers operating for more than a decade, DV 78 is the standard transport unit for LLW from AREVA’s reprocessing plants to the ANDRA sites

Figure 1 : DV 78 package

This standard has been adapted to specific requirements of customers in the DV 79 specific version to qualify as an IP 3 package.

CC102 over pack

The CC102 package is an example of a specific response to a client need:

- The customer need : a packaging for concrete primary package, very irradiating with important volume,
- The TN International response: the CC102 package, a package with possibility of automatic loading in the reprocessing plant.

A solution for liquid waste from NPPs : TN™CIEL

Because of its number of nuclear power plants in operation, EDF (Electricité de France) has a comprehensive approach to the waste management issues. Operators training, awareness and volume reduction are an everyday issue of waste management. Of course, there is concern to use the best practice and the best tools. Going through one of the processes of thought described above, TN International has developed an original concept for contaminated boron acid from the nuclear power plants.

Rather than processing it on each site, or trying to modify it in some ways, EDF elected to have a TN International design and to create an original liquid waste transport tank packaging, the TN™CIEL (fig.4). The tank is a type IP2 according to IAEA, and is qualified according to regulations for radioactive materials and for corrosive hazardous goods. Because boric acid sets at room temperature into a rock hard substance, the tank is shielded and has heat tracers to keep it above 50°C. In addition, it has its own generator in order to keep heating even when the truck does not work.

With this system, each of the EDF reactors are visited once to twice a year, relieved of their boric acid residues, that are shipped in the TN™CIEL to the CENTRACO incineration facility in Marcoule: EDF combines thus an efficient incineration facility with simple effluent vessels at the power plants, together with a practical shipment scheme.

Benefits from this approach are clearly minimizing on site equipment at each nuclear power plant, minimizing dose intake to operators, and relying on a most efficient facility, CENTRACO.

The tank has been in operation since 2001 and around 130 transports have been realized that is representing around 520 tons of boric acid.
This development of packaging is an example of partnership between the producer (EDF) and the package developer (TN International) that has permitted an optimization of transport and by consequence a cost reduction for the producer.

Contents:
5 m^3 of Low Specific Activity of Category II such as concentrates of boric acid
TN™ CIEL is also qualified as a Class 8 container for corrosive goods.

Dimensional:
Overall length : 8900 mm
Overall width : 2500 mm
Overall height : 3500 mm
Maximum allowable tank volume : 5 m^3
Maximum mass of the loaded semi-trailer : 33 t
Maximum mass of the loaded articulated vehicle:40t

IP 2 type packaging :
- An Uranus containment system,
- A radiological protection in carbon steel,
- A unit of heating electrical resistances supplied by a generator,
- An insulating system fixed on a 3 axes trailer,
- A remote control unit to operate the system,
- A power generator,

A device for depressurizing or pressurizing the containment system.

Activity content :
Maximum activity is 20 000 Bq/g (ecquerel/gram) of gamma emitting nuclides
Total admissible activity in the tank is 0.1 TBq (Terabecquerel) (or 2.7 Ci = Curie)

Figure 2 : TN™CIEL Tank

TN™GEMINI for the transport of alpha waste

Alpha waste is generated in fuel cycle facilities such as those involved in reprocessing and in manufacturing mixed oxide fuel, and in research laboratories. If a significant amount of waste has to be transported, then a Type B packaging is required. Developed by TN International, the TN™GEMINI container enables nuclear facilities operators to optimise their alpha waste transport management, and more generally contributes to their D&D projects achievement.
Operating a versatile package for waste provides new solutions for the operators: they can envisage to ship larger parts to a repository or centralized conditioning facility. In order to make full use of its capabilities, two on going processes are essential:
- To strictly implement waste sorting and characterization policy in facilities,
- To measure gas release and use systematical return of experience, in order to quantify it conservatively but without overestimation.

Large alpha waste packaging is a key for an efficient waste management system and contributes to decrease the number of transport operations.
The TN™GEMINI (Fig.4) package is a parallelepiped with a rear door allowing horizontal loading. It is similar to an ISO 20 ft container in terms of outside, size, handling devices and tie-down capability. It provides a large

internal usable volume (4.5 x 1.8 x 2 m) available for a 5.8 t payload with a 30 t total gross weight. The maximum licensed fissile contents have been set at 370 g of plutonium.

Dedicated internal arrangements such as pallets are used for loading, unloading and tie down of the drums. They can be loaded/unloaded with a fork lift in a manual mode or with dedicated equipment in a semi automated mode.

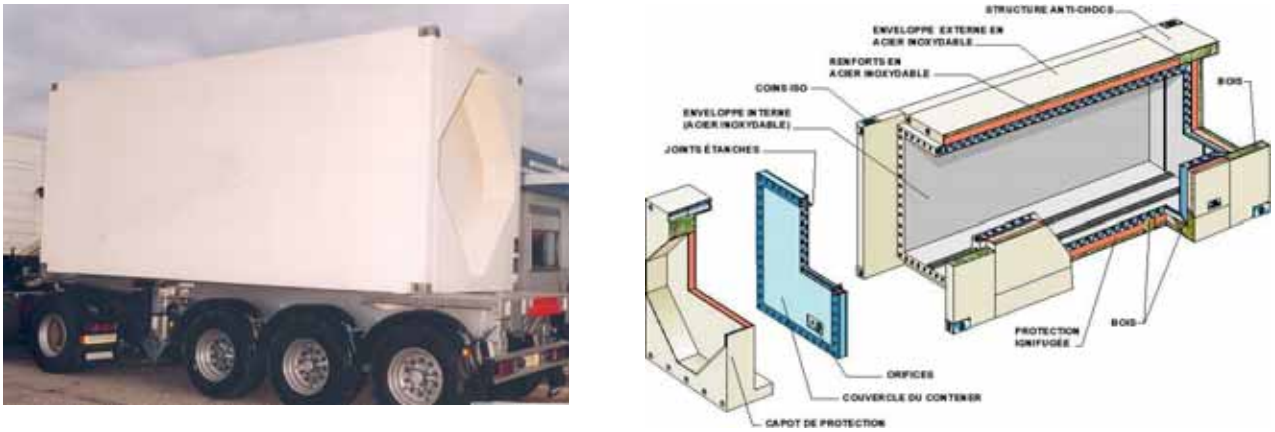


Figure 3: The TN™GEMINI and its trailer on the road and sketch of the structural design of the TN™Gemini

The TN™GEMINI (figure 3) has been initially developed to transport forty 200 liters drums or sixty 118 liters drums full of contaminated waste. It now accepts 400 and 600 liters drums. The body is a patented multilayered structure (figure 3) designed for fire resistance and containment integrity, both after 9 m regulatory drop tests and the punch test, which is especially severe for large flat surfaces.

Stainless steel brings corrosion and structural resistance. It offers easy to decontaminate surfaces. Wood is used as energy absorber at key impact locations. An insulating medium provides thermal insulation that keeps the internal within an acceptable temperature range under the regulatory fire accident. Because of the significant quantity of organic waste, the temperature of the contents under fire accident should stay below 70°C.

The global mass of the packaging, together with its dedicated trailer, makes it possible to stay below the 40 t limit. It is thus possible to perform transports without constraints of exceptional transport.

Key design issues were the punch bar test resistance and the choice of an horizontal loading system.

- Overall dimensions 6058 x 2500 x 2650 mm
- Free volume 4510 x 1840 x 2000 mm
- Total gross weight 30 000 kg
- Maximum payload 5 800 kg

The TN™GEMINI is a B(M)F packaging. It is licensed for transport in France and United-Kingdom according to IAEA 1996. Key issues in licensing were linked to the definition of the waste array included. Types of waste to be considered are very various (paper, polymers, metals, glass, etc.).

Hydrogen production due to radiolysis or chemical decomposition of organic materials is taken into account. Permeability envelope characterization for an acceptable H_2/air ratio has been performed. When evaluating a payload for performance, consideration is given to the type and characteristics of plastic foil wraps, to make sure that no excessive retention of hydrogen is to be feared. In case the H_2 production is high, then a limit on the duration of the transport is set, so that no excessive accumulation takes place.

The TN™GEMINI has now been under operation for 12 years and has currently two main lines of use:

a) Transporting α contaminated wastes from the MELOX plant to the waste processing facilities of AREVA-La Hague reprocessing plant,
b) Transporting α contaminated wastes from CEA (Commissariat à l'Energie Atomique) facilities to α waste treatment facilities

Usage a) is an industrial operation, and makes full use of the TN™GEMINI operational features such as the loading platform allowing pallets carrying drums to roll horizontally into the cavity (figure 3) before being tied down. The backup is part of the logistics system of the MELOX plant, and convenient preparation areas are handy to prepare drum pallets.

RD 26 package

The RD 26 package is a B(U) packaging which was developed for the transport of one drum of 118 liters type. This means that this flask can be considered as a complementary equipment to the TN™GEMINI cask: only one drum is transported in each flask.

The RD 26 package has a cylindrical shape and is mainly composed of:

- a body made of an internal stainless steel containment, a specific material acting as a neutron shielding and a thermal protection, and an outer stainless steel envelope.
- a lid bolted onto the body and equipped with an orifice in order to take a sample of the gas cavity before opening the flask.
- two elastomer gaskets between which a check of the leaktightness can be performed before the transport.
- a shock absorber cover bolted onto the body and mainly made of wood.
- a short frame for handling operation.

The maximum loaded weight is 610 kg for a 118 liters drum of 150 kg. The height is 1145 mm (with the shock absorber) and the outer diameter is 860 mm. During transport, each drum is placed in a RD 26 flask and twelve of them can be transported by road at the same time in a DV 78 container (fig.1).

Bituminized waste (ILW) : the TN™833

The TN™833 cask is developed to transport bituminized residues coming from spent fuel reprocessing to their owners (Spain, etc.).

Its design has consequently to be compliant with the AREVA-La Hague DE/EB facility mechanical interfaces: mass less than 40 tons, loading / unloading operations with trunnions, for instance.

The TN™833 will be available from 2010 and is intended to be a type B(U) package. It will be transportable, by road or rail, vertically tied-down on a flat ISO 20’ frame directly loaded on a wagon or a truck.

The TN™833 capacity is 12 bitumen drums by cask, in two lays. This cask is made of stainless steel with external heat insulator on the body and inside the lid. The shock absorber cover, on the top, is made of aluminium and contains insulating material also.

⇨ a cylindrical body (external diameter : 2330 mm), equipped with two trunnions
⇨ a lid : a thick disc equipped with an orifice (same location and design as TN™28) and an handling device
⇨ one top shock absorber made of aluminum with internal heat insulating material (external diameter : 2700 mm)
⇨ two internal baskets, each for 6 bitumen drums

- ⇨ Total height : 2680 mm
- ⇨ Total gross weight : 40 tons
- ⇨ Content weight : 6.8 tons
- ⇨ Lid cover weight : 2.5 tons

Technological waste in CBFC’2 (ILW): the TN™837

The TN™837 cask is being developed to transport technological waste included in concrete matrix, in a packaging called CBFC’2, mainly in order to allow AREVA to return this waste from AREVA La Hague plant to Spain.
Its design has consequently to be compliant with the AREVA-La Hague plant DE/EDS facility mechanical interfaces: mass less than 50 tons, loading / unloading operations with trunnions, for instance.

The TN™837 will be available when the first return will be required and is intended to be a type B(U) package. It will be transportable, by road or rail, vertically tied-down on a flat ISO 20’ frame directly loaded on a wagon or a truck. This transport frame has the same design as for the TN™833.

The TN™837 capacity is of 3 CBFC’2 by cask. This cask is made of stainless steel, with a top shock absorber made of aluminum.

- ⇨ 1 cylindrical body (external diameter : 2530 mm), equipped with 2 trunnions
- ⇨ 1 lid : thick disc equipped with an orifice (same location and design as TN28) and an handling device
- ⇨ 1 top shock absorber made of aluminum (external diameter : 3000 mm)
- ⇨ 1 internal basket for 3 CBFC’2
- ⇨ Total height : 2355 mm
- ⇨ Total gross weight : 46 tons
- ⇨ Content weight : 12 tons
- ⇨ Lid cover weight : 3 tons

Universal Canisters for Vitrified waste (HLW) and Compacted waste (ILW)

In partnership with its customers AREVA has implemented a policy of waste volume reduction and conditioning. Several different types of conditioning for residues were initially considered. This would have multiplied the number of transports. Firstly, the glass canister has been designed. The shape and the characteristics of the canisters have been designed to be easily handled either by cranes or by a loading-unloading machine. When AREVA NC (formerly COGEMA) decided to compact hulls and end pieces, and to select a container, the stainless steel canister for vitrified residues was chosen as a multipurpose container named the Universal Canister (UC) also called CSD-C and CSD-V. Moreover, vitrified residues waste form have been licensed by the French Authorities and Safety Authorities from Belgium, Japan, Germany, Switzerland, United-Kingdom and The Netherlands, making the glass canister to an universal standard.

The Universal Canisters are used as container for:
- the hulls and end pieces produced at ACC (*Atelier de Compactage des Coques*) facility at AREVA-La Hague plant ; the resulting canister is named CSD-C,
- the fission products immobilized in a glass matrix produced in R7/T7 facility ; the resulting canister is named CSD-V.

Vitrified waste (HLW)

In order to deliver canisters in the best technical and economical conditions, TN International has designed for AREVA and its customers two solutions depending on the facility which will receive the waste:

- In Belgium, The Netherlands and Japan vault facilities are ready to house the canisters. Therefore the transport solution developed is a fleet of routine transport casks (TN™28).
- Germany and Switzerland have opted for a uniform handling of waste and of vitrified residues, in dual purpose transport/storage casks such as TS 28, TN™81 and TN™85 casks. In this case, the proposed solutions allow to transport and to store the canisters.

Transport solutions for CSD-V canisters: the TN™28 VT

For the transport of the vitrified residues, an IAEA type (B) packaging is necessary. The TN™28 VT (fig. 4) is the transport cask proposed by TN International for this type of waste.

The subassemblies of the cask satisfactorily perform the various functions that are essential to safety. The transport cover acts as a mechanical shock absorber during severe impacts or shocks, and thermal insulation for the cask lid in case of fire. The body and the closing system guarantee that radioactive materials will be confined, reduction of radiological radiation emitted by radioactive materials and dissipation of thermal power released by radioactive materials

This flask is composed of the following subassemblies:

- The basic structure is a cylindrical receptacle formed mainly from a thick shell made of carbon steel comprising an internal cylindrical cavity in which the glass canisters to be transported are placed. The thickness of the forged steel shell forms the main gamma shielding,
- The body is equipped with two pairs of bolted removable trunnions for handling, tilting and stowing,
- Inside the cavity, an aluminium basket is fitted and provides a structural support for the CSD-V canisters. Thermal power released by such canisters could possibly be going up to 2 kW after production according to the AREVA specification. So, this cask has 2 basket designs allowing transporting either 20 canisters, releasing each one up to 2 kW for a maximum thermal output of 40 kW, or 28 canisters, with a maximum canister heat release of 1.46 kW each, and total heat output of 41 kW. The canisters are stacked on four levels.
- Surrounding the cylindrical cavity, blocks on polyester resin provide neutron shielding features of the cask. The bottom of the cask and the lid are also equipped with a similar neutron shielding. Shaped copper plates separating resin compartments, crimped along their length by welding cover plates forming the outer envelope, and in tangential contact with the forged shell, ensure the thermal evacuation of the heat power released by the vitrified residues to the outer shell, itself in contact with ambient air.
- The closing system of the cavity entrance is composed of a lid with two elastomer gaskets. The lid is held in place by its flange fixed to the shell by bolts that keep its two O-rings embedded in the grooves leak tight. An orifice passing through the lid provides access to the cavity and is used to create a vacuum in the cavity and for filling it with a neutral gas, or adjustment of internal pressure, or taking a gas sample.
- Two shock absorbers are placed on the top and the bottom of the flask for lateral and axial drops.

Main design characteristics of the TN™28 VT :

- ⇨ Overall length with shock absorbers: 6 607 mm
- ⇨ Length without shock absorbers: 6 105 mm
- ⇨ Maximum diameter with trunnions 2 480 mm
- ⇨ Maximum weight loaded with shock absorbers: 112 tons
- ⇨ Internal diameter of the cavity 1385 mm

- ⇨ Weight empty : 94,7 tons
- ⇨ Pay-load : 10 tons for the loading of 20 canisters or
  14 tons for the loading of 28 canisters

Figure 4 : TN™28 VT cask

The TN™28 VT design has been licensed for several years and flasks have been currently in operation since 1995 for the transport of vitrified residues from the La Hague reprocessing plant to the Interim Storage sites in Japan, Belgium and the Netherlands.

Dual purpose solutions for CSD-V canisters: the TS 28

From the mid nineties, industrials started to design dual purpose flasks. One type of transport interim storage casks has been developed by TN International to serve these markets, and basically travel either in Germany and Switzerland: the TS 28, with a maximum heat output of 41 kW.
The TS 28 design is almost identical to the TN™28, but it was designed for the storage of canisters too. The main differences are: the gaskets are metallic instead of elastomer, for the storage configuration and an eventual second transport and the top of the flask is equipped with a secondary lid. The TS 28 design is licensed in France for the transport and in Germany for the transport and the storage at Gorleben. Transport of vitrified residues back to Germany with TS 28 flask has been performed. This cask was the first one to be loaded with HLW canisters and transported to Germany.

The flask safety approval induces different type of constraints (activity, thermal power, weight, etc.) on the selection of the HLW canisters to be transported. These constraints usually remain stable in time, whereas HLW canisters characteristics tend to grow towards the specified production limits due to higher burn-up fuels being reprocessed (inducing higher contents on activity, such as Curium 244 for instance),

Adding to the specific needs expressed by the customers and their Authorities for the acceptance on their territory, the first generation HLW casks imposed selection process of loaded canisters. New casks with a target of 56 kW thermal output capabilities and increased activity limits have been designed: the TN™81 and TN™85 casks. The first TN™81 units have been loaded in AREVA-La Hague reprocessing plant, and are stored in Switzerland at Zwilag.

In parallel, we keep on working on other types of flasks such as TN™85, which will be available in year 2007 and enable a continuous flow of returns to Germany. (see ID 7222).

CSD-V programme of return

The current transport programme from AREVA La Hague plant is the following:

- Japan : One transport per year with up to 8 flasks
- Germany : One transport per year with up to 12 flasks
- Belgium : Two transports per year, with one flask
- Netherlands : One transport per year, with one flask
- Switzerland : One or two transports per year, with one or two flasks

The fleet of transport flasks was determined according to the following considerations:

- For Japanese returns, a maximum of 8 flasks transported per year to Japan in one maritime voyage, taking into account the longer transport duration by sea, flask unloading and the necessary return of the emptied flasks by batches (cost optimisation) to La Hague for flask maintenance operations and re-loading. 12 TN™28 VT were manufactured for the Japanese HLW returns.
- For Belgium and the Netherlands, taking into account a total of 3 returns per year to both countries, one TN™28 VT was manufactured for both clients.
- For Germany and Switzerland, as the flasks are used for interim storage, the size of the fleet is simply the total number of canisters to be returned divided by the quantity of canisters per flask (28).

Since 1995 (date of the first return) and up to now, 4 166 CSD-V have been return among the 5 622 to be returned:

- 12 returns to Japan in TN™28 VT
- 9 returns to Germany in Castor or in TN™85 in the future
- 13 returns to Belgium in TN™28 VT
- 11 returns to Switzerland in Castor or TN™81
- 3 returns to Netherlands in TN™28 VT

Compacted waste (ILW): the TN™843

Further to ramp-up of operations of the ACC workshop at AREVA La Hague plant, TN International has started with AREVA and its customers the organization of the return of the CSD-C canisters with the objective to perform the first return to the European countries before 2010.

Based on the CSD-V return of experience since 1995, TN International has studied the preliminary design of a new cask for CSD-C canisters. According to the specific characteristics of the CSD-C, especially the low thermal power and high activity of the waste conditioned and taking into account all the transport constraints, a cask with a higher capacity has been designed. This presents the important advantage to reduce the number of transports.

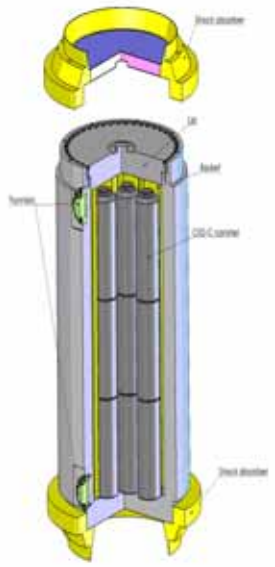
For the transport of the compacted residue an IAEA type (B) packaging is necessary. As for the CSD-V returns, two concepts of casks were then studied depending, on the final or interim storage:

- a concept for transport only,
- a concept for transport and interim storage.

These two concepts are compatible with minor adaptations with the TN International existing transport means and can be transported by road, rail and sea.
Our description is today limited to the transport concept, the cask named TN™843 : see Figure 6 below.

All main features of the TN™843 are similar to the other heavy flasks: a body composed of a thick forged carbon steel shell welded to a forged bottom and covered by a lid equipped with elastomer gaskets and an orifice (same location and design as the TN™28 VT cask). To complete the gamma shielding, a lead layer surrounds the inner shell on the cavity height. Lead is surrounded by a thin carbon steel shell.
The internal basket is made of aluminum tubes and can retain 36 canisters, in three layers of 12 canisters each.

During transport, the flask is protected by two aluminum shock absorbers.



Main design characteristics of the TN™843 :

- ⇨ Overall length with shock absorbers: 5 350 mm
- ⇨ Length without shock absorbers: 4 550 mm
- ⇨ Maximum external diameter with shock absorbers: 2 790 mm
- ⇨ Internal diameter of the cavity: 840 mm
- ⇨ Height of the cavity: 3 900 mm
- ⇨ Maximum weight loaded, with shock absorbers: 118 tons
- ⇨ Weight loaded, without shock absorbers: 112 tons
- ⇨ Pay-load : 27 tons for 36 compacted UC-C Universal Canisters

Figure 5 : TN™843 cask

CONCLUSION

TN International experience in designing packages and transporting nuclear materials is part of the AREVA waste management policy, which aims to waste volume reduction through waste sorting and packaging in universal canisters or standard waste containers.

For the design and manufacture of special shipping casks, as for nuclear transportation and storage, TN International tailors its solutions to its international customers’ requirements. Personnel safety, transportation safety and environmental protection are put first.

These reasons have lead TN International to become the world's leading designer of nuclear fuel packages, with unique expertise in designing packages for back-end transportation and storage of nuclear materials.

Beyond being a transport company and packaging designer, TN International is a partner implementing logistics skills and supporting producers to achieve their waste management targets.

The different entities of the AREVA Business Unit Logistics (TN International, TRANSNUCLEAR Inc., TRANSNUCLEAR Ltd., LMC, MAINCO) have indeed proven their ability to mobilize expertise at key steps of the waste logistical chain in supplying efficient, reliable and safe transport solutions. These entities constitute a world-wide transport network able to supply both tailor made and standardized solutions, under constant and strict compliance with international regulations. The AREVA Business Unit Logistics is indeed the only one player in the nuclear world able to cover the whole waste management policy with competencies at all technical levels.

The next 10 years will be a cornerstone for waste management: industrial producers will have to cope with many challenges, such as larger flows of LLW and VLLW issued of dismantling operations. The AREVA Business Unit Logistics will be the partner of producers facing with them the future challenges, by improving current solutions and developing innovative solutions.